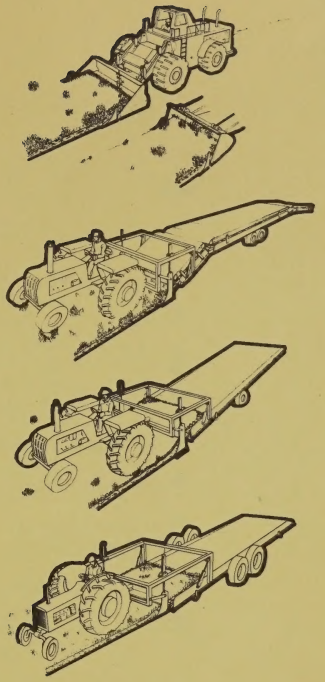
BLM LIBRARY
88079033

Concepts
SOD MOVER

August 1978



FOREST SERVICE
EQUIPMENT DEVELOPMENT CENTER
MISSOULA, MONTANA

BUREAU OF LAND MANAGEMENT

TA
725
.C74
1978
c.2

7842 2502

#8032801
ID: 88079033
TA
725
.C74
1978
C.2

CONTENTS

Page

GENERAL CONSIDERATIONS. 1

COMMON FEATURES. 1

TRAILER-TYPE SOD MOVERS 2

Tilt-bed, open-topped sod mover. 2
Tandem-wheel, tilt-bed, open-topped sod mover. 5
Double-belted trailer systems 6
Large cylinder sodder 7
Other Considerations. 8

FRONT-END LOADER SOD MOVER 8

Sod-handling package 9
Sod system 10

FEASIBILITY. 10

COSTS 10

BLM Library
Denver Federal Center
Bldg. 85, OC-521
P.O. Box 25047
Denver, CO 80225

7842 2502

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

"Surface mining, by its very nature, destroys the original soil mantle of the mine site. Topsoil salvage reserves a portion of the developed soil, but the salvage process itself destroys or alters many important physical characteristics of the soil system which developed over thousands of years. This time development factor cannot be duplicated, but if reclamation is to be permanent, every effort must be made to approximate it." [1]

GENERAL CONSIDERATIONS

Moving the soil surface as a unit or slab is one possible method to salvage the "original soil mantle" with a minimum of damage. A slab should preserve the original soil structure with much of the original vegetation left intact and greatly enhance the survival rate on western surface-mined lands.

This procedure is common to commercial sod suppliers for establishing instant lawns. However, using sod as part of the effort to reclaim western surface mined land is more difficult. Vegetation is often very sparse because of minimal soil moisture and overgrazing. Root masses are inadequate to bind the sod together. To assure successful revegetation on such land, soil should be up to 12 inches deep and should be moved as much intact as possible.

Equipment to move slabs of soil 12 inches deep would have to incorporate features of equipment for handling loose soils (like that used in road construction) as well as the features of the commercial sod machines. Weight and looseness of the soil restrict the development of a sod mover for reclaiming western lands.

Cost would probably prohibit resodding an entire area marked for reclamation. Scrapers would still do the bulk of the subsoil and topsoil moving, but sod slabs could be useful to stabilize critical areas like draws or gullies where water runoff causes erosion. In addition, slabs of shrubs could be moved intact with a sod mover.

Representatives of Bureau of Land Management - EMRIA, Montana State University, Reclamation Research, and the Missoula Equipment Development Center met to exchange ideas for sod movers. Several concepts were envisioned which fall into two categories: (1) Trailer-types to be towed by a farm tractor; or (2) a device to convert a front-end loader to a sod mover.

COMMON FEATURES

A rubber and fabric belt to load, carry, and unload the sod would be common to both machine categories. The belt would provide a non-porous surface to retain the soil intact. And, according to sources in the conveyor industry, a belt will not elevate loose material steeper than 18°, even with special traction.[2] The maximum slope to load and unload the belt in either category of machine would be 18°.

We also are restricted by weight of the load of 100 pounds per cubic foot of soil. The weight affects tire size, compaction, and power as well. Each category would also have sideboards arranged to prevent spilling soil from the belt.

All of the concepts have the edge framework and pulley shaft bearings in contact with the soil during excavation. Any parts of the system that extend outside of the belts and contact the soil will have to bulldoze their way through the uncut soil. There will then be loose soil and rock that can work its way under the belt and could jam or damage the belt. To reduce these problems, "wing" pulleys should be used wherever possible (fig. 1). The segmented design of these pulleys allows the debris to be swallowed and then expelled along the shaft. Pulleys, which would be 96 inches wide, are not "off-the-shelf" items. They are available on special order, and will probably have to carry two 48-inch belts vulcanized together, since the widest belts generally available are those 72 inches wide.

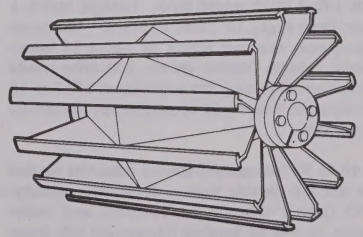


Figure 1.--Wing pulley.

TRAILER-TYPE SOD MOVERS

A vibrating or oscillating blade would be necessary to undercut the soil for the trailer-type machine to reduce the tractive load on the towing vehicle tires and to reduce the soil disturbance ahead of the undercutter. An oscillating blade would not reduce the size of the tractor required because although total draft forces can be reduced appreciably by this oscillating tool method, total power consumption may not be reduced since the energy saved in reduction of draft is about equal to the energy required to oscillate the tool. [3] For example, drawbar horsepower equals 12½ horsepower for a stationary cutter blade and is reduced 40 percent by an oscillating blade, so that power distribution is about 7½ horsepower to the tractor wheels and 5 horsepower to the oscillating blade--probably from the tractor PTO (power takeoff).[4]

Power is also required to lift the soil slab up an incline for loading. For example, a trailer built with a tilting bed to haul an 8-foot by 20-foot slab 1-foot thick would have: Loading speed, 1 mph; Deck angle, 18^{o}; soil, 100 lb/ft^{3}. Maximum horsepower required would be about 13 horsepower. System friction on the belt drive would add about 20 percent for a maximum of 15 to 16 horsepower. This could be supplied by the tractor hydraulics.

A 40 to 50 horsepower tractor would be needed for the sod moving system. Hydraulic capacity, PTO (power takeoff) performance, and trailer design, as well as drawbar horsepower will determine the type of tractor to be used.

Our investigation shows that knowledge of vibratory tillage is very limited, although research is continuing. Designers use a "best guess" based on available information and then refine the design through test and modification procedures. All variables like tool angles, tillage depth, oscillating amplitude, and soil type have not been investigated. There is some concern, for example, about the danger of high energy levels from vibratory machines to equipment and bystanders. A dealer for a vibratory cable-burying machine suggests that the blade may remain stationary while the trailer shakes. [5]

Any development program would have to take into account the lack of hard design parameters and include extensive test and modification procedures.

Trailer-type sod movers could include:

1. Tilt-bed, open-topped sod mover.—This might be considered a basic design because of the simplicity of the system. It is a conveyor belt mounted on wheels. Power for the belt may be supplied by ground traction, tractor hydraulics, or tractor PTO. The drive must engage the belt near the center of the trailer to avoid interference of drive components with the ground during both loading and unloading (figs. 2 and 3).

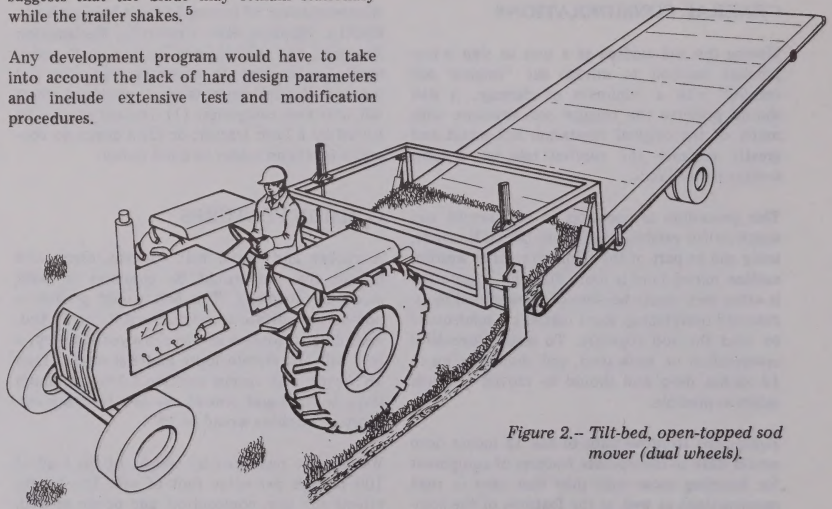


Figure 2.-- Tilt-bed, open-topped sod mover (dual wheels).

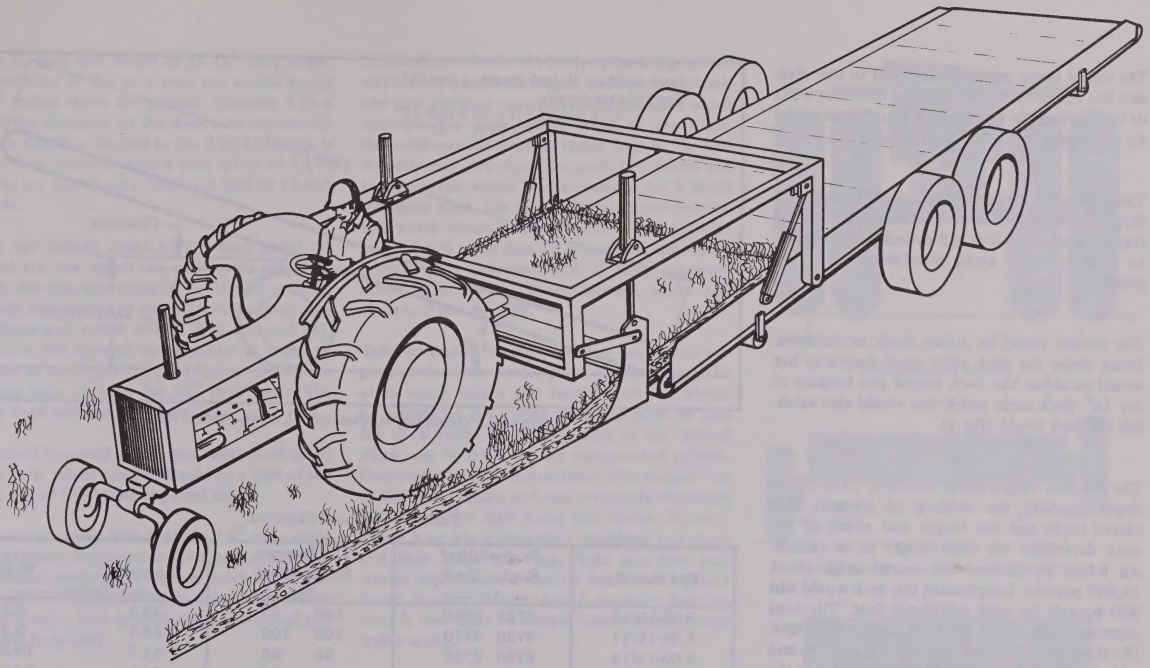


Figure 3.– Tilt-bed, open-topped sod mover (tandem wheels).

The cutter blade would be attached to the hitch and the vibratory drive would be driven by PTO or hydraulics. The cutter blade would be retracted by a hydraulic cylinder for transporting.

The deck angle would be hydraulically controlled through cylinders between the hitch and conveyor frame. Again the hitch and cylinders would have to be located to avoid interference with the ground.

The wheels could be either duals or tandems. Duals under the deck offer great simplicity but would establish the deck height and because of the 18° deck angle restriction would also establish the deck length (fig. 4).

The soil slab weighs about 100 lb/ft^3. The 1-foot depth required for sodding on western strip mined lands and the length and width of the deck determine the total weight to be carried. An 8-foot by 20-foot slab would weigh about 16,000 pounds. Lengthening the deck would add 800 pounds for each additional foot. Tire load capacities and diameter determine deck height. On the table, find the diameter of the tire and add 3 to 4 inches for clearance to establish the deck height.

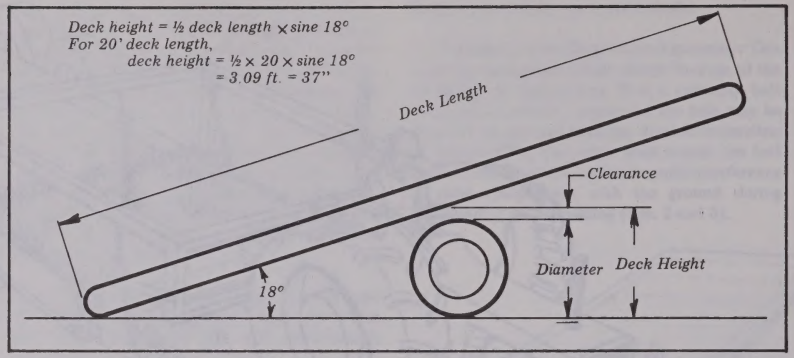


Figure 4.-- Geometry of dual-wheel, open-topped trailer.

Table 1.- Tire specifications

Tire Size/Ply	Payload/tire*		Tire Pressure		Diameter	Width
	Single	Dual	Single	Dual		
	------Lb------		-----Psi-----		----------Inches---------	
8.25-15/12	3720	3260	100	90	33.3	9.3
8.25-15/14	3720	3470	100	100	33.3	9.3
9.00-15/12	4290	3760	95	85	34.7	10.3
10.00-15/12	4540	3940	85	75	36.2	10.8
8.25-20/10	4050	3550	85	75	38.7	9.6
8.25-20/12	4500	3950	100	90	38.7	9.6
9.00-20/10	4610	4040	80	70	40.1	10.6
9.00-20/12	5150	—	95	—	40.1	10.6
10.00-20/12	5430	—	85	—	41.5	11.0

*for trailer service at 60 mph

For a 20-foot bed length at an 18° deck angle, the midpoint of the deck over the wheels would be 37 inches above the ground. Allowing 3 to 4 inches for clearance of the deck over the wheels, the tire would be limited to the 8.25-15, which is a 33.3-inch diameter with a load rating of 3,470 pounds per tire (duals), or a total load of 13,880 pounds.

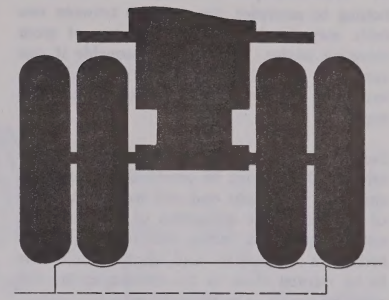
These tire ratings could be increased about 20 percent for low speed use with some risk. This would increase the capacity to 16,605 pounds. The soil slab weight of about 16,000 pounds and the trailer and cutter weight of 4,000 to 5,000 pounds is well beyond tire capacity. It might be possible to use bigger tires, but that would require a longer deck to hold the 18° deck angle. The longer deck adds more payload.

A detailed trade-off of tire size versus deck angle versus total wheel loading would be a part of the design job of this trailer-type sod mover.

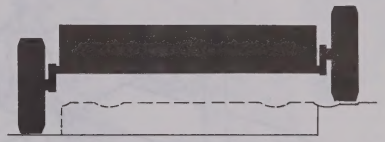
It should be noted here that the 18° ramp angle is a maximum. Engineers in the conveyor industry recommend keeping the angle as much below 18° as possible. Also, an 18° angle would place limits in operation to level ground, or uphill to load and downhill to unload.

2. Tandem-wheel, tilt-bed, open-topped sod mover.—To avoid the length, width, and payload-tire size problem encountered in the dual wheel concept, the tires would need to be bogie-mounted outside the belt frame (fig. 3). Tires of virtually any size could be used, but would add to the overall width. If, for example, the 8.25-20 tire were used, the total width increase beyond belt width would be over 3 feet. Wheel width of both tires is more than 19 inches plus suspension framing plus clearance, and, if used, a ground driven belt system. These features would add close to 2 feet per side.

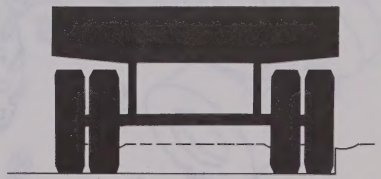
Tandem wheels would require a bogie-type suspension to allow center pivot of the trailer. The extra width would also require that the wheels be adjustable for height from the deck so that the deck could be kept parallel to the ground when one wheel is on the unexcavated ground. Problems would be encountered with compaction of the unexcavated sod and previously deposited sod beside the slab being laid down. Figure 5 shows how the compaction problems can occur and how duals will help. Note also that dual wheels will permit a narrow trailer for highway travel; tandem wheels should require a belt less than 5 feet wide to remain under 8 feet overall trailer width.



Compaction by tractor



Added compaction by tandem trailer



No added compaction by dual-wheel trailer

Figure 5.-- Compaction illustrations.

3. Double-belted trailer systems.— Double belting to sandwich the sod slab between two belts may be feasible to allow use of steep elevating angles. This seems reasonable if one considers that the top belt will provide an extraction surface as well as hold the soil slab together.

Some problems with a double-belted system are evident. Drives must be provided for both belts and that would add cost and weight. A means of controlling the separation of the two belts must be provided, which adds to the cost and belt drive complexity. And, shrubs would have to be mowed close to the ground so the slab could be conveyed between the belts.

Figure 6 shows a double belt concept. The double belt could also be used with the tilting deck system in the first two concepts. We do not know how much increase in the ramp angle will be gained nor how destructive to plants the double-belt trailer would be without testing.

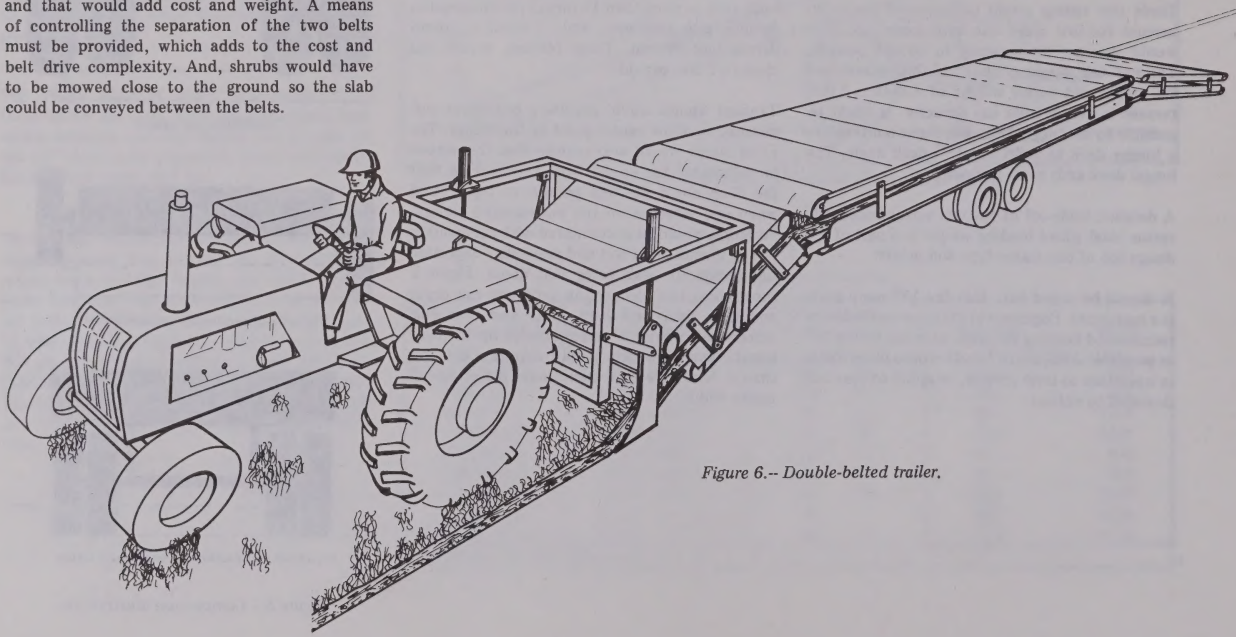


Figure 6.-- Double-belted trailer.

A representative of the conveyor industry questioned the feasibility of the double belt because the lower belt would be more heavily loaded than the upper belt: (1) The lower belt would stretch more than the upper belt giving the lower belt a slower apparent speed; (2) there would be more slippage between the lower belt and drive pulley, which would add to the belt speed difference; (3) where the upper belt contacts vegetation, the lower belt contacts soil, which would result in a greater amount of debris in the lower belt system and add to slippage; and (4) the lower belt works in the soil during the load and unload activities, which would add resistance to the lower belt.

A means of controlling the belt speed between the upper and lower belts would have to be provided.

4. Large cylinder sodder.—This would roll the sod around a large diameter cylinder with a belt to compress the sod against the cylinder. (fig. 7)

The cylinder system shows mechanical and operational advantages over flat deck trailers. The wheels may be placed behind the cylinder for holding width down and for depth control. The assembly is relatively short for maneuverability. No tilting mechanism is needed.

Disadvantages of the system would be a complex belt adjustment to hold the sod slab between the cylinder and belt; reduced driver visibility of the cutter head compared to the flat deck concepts; and all the disadvantages of a double-belted system would be included as well.

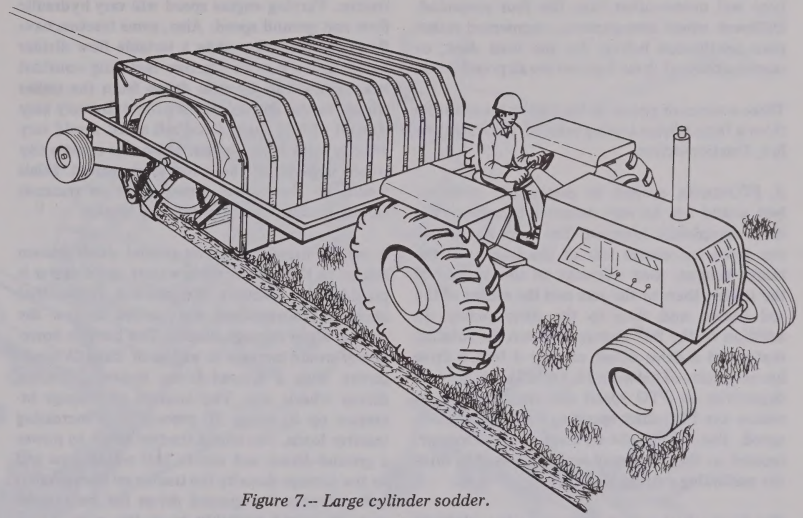


Figure 7.-- Large cylinder sodder.

Other Considerations

There are many possible concepts for the trailer-type sod mover other than the four presented. Different wheel arrangements, segmented rather than continuous belting for the load deck, or combinations of these features are all possibilities.

Three sources of power to the trailers are available from a farm tractor towing vehicle: PTO, Hydraulics, Traction-driven.

A PTO-driven system to power the conveyor belt would not be very desirable because of the drive complexity involved. The drive line would run from the center rear of the tractor to the trailer tongue, then sideways to the outside of the trailer, then to the rear and the center of the sod trailer, and then to the drive pulley. In addition to the 90^{o} change between the rotating shafts and a drive offset of over 4 feet, a drive line reduction of between 15:1 and 35:1 is needed, depending on PTO speed and engine speed, to reduce the PTO shaft speed to the conveyor belt speed. The PTO shafts on tractors are, however, located so that they may readily be used to drive the oscillating cutting blade.

The tractor hydraulic system presents a relatively easy method of directing tractor power to the belt drive. Two hoses and a properly sized hydraulic motor are all that is needed. Speed controls would depend on make and model of the towing tractor. Varying engine speed will vary hydraulic flow and ground speed. Also, some tractors have flow rate controls, while a variable flow divider could be used with tractors featuring constant volume systems. Ground drives from the trailer wheels to the conveyor belt offer extremely easy control of belt speed since belt speed would vary directly with wheel speed. Drive line complexity would depend on the wheel arrangement. Duals would be the easiest arrangement to transmit torque through chain drive to the wheels.

A serious drawback to the ground wheel system relates to the tractor drive wheels, since power is provided by traction. We showed earlier that about 7½ horsepower was needed to tow the cutting blade through the soil. The tractive horsepower would increase to a total of 20 to 25 horsepower with a ground-driven system. Traction driven wheels slip. The amount of slippage increases up to about 20 percent with increasing tractive loads. The added tractive effort to power a ground-driven sod mover belt would thus add to the damage done by the tractor on unexcavated soil. Slippage for ground drives for trailer-type systems would probably be in the range of 10 percent.

FRONT-END LOADER SOD MOVER

Large front-end loaders are used at all surface mines. They might be considered the utility vehicle of surface mining, and are therefore a logical candidate for modification in to a sod mover. End loaders have already been used to transplant trees, sod, and shrubs, with some success. Tree transplanting with an end loader often disturbs the roots and soil around the roots too much. Sod and shrub pad transplanting works reasonably well, but the severe angle needed to slide the pads out of the bucket causes the pads to split or crack when they are bent to lay flat on the ground. The condition is aggravated because the end loader is backed up to drag the pad out of the bucket. The tensile loading of the pad separates segments and leaves voids. A skim of soil is generally placed on the pad to seal the voids.

Using a powered conveyor system over the bucket deck to load and unload the bucket appears to be a reasonable approach. The load would be forced by vehicle tractive effort up a short ramp and then conveyed by the belt to complete the loading process. Unloading might well be where the largest benefit occurs; no steep angles or bucket shaking should be needed. The overall effect should reduce soil pad damage.

Two methods for modifying the front-end loader are (1) adding a sod handling package to the bucket, and (2) replacing the bucket with a sod system.

1. Sod-handling package.—Figure 8 shows, schematically, placement of a conveyor belt deck in a loader bucket with a bucket blade edge extension to form a ramp for loading. Note that the rear of the bucket curves forward over the deck to form the bucket. The curvature is necessary to retain a load during normal excavating operations. During transplanting of shrubs, such as aspen, the top edge of the back bucket wall contacts the shrub and bends them over and disturbs the roots and soil. A conveyor belt deck added to an existing bucket would place the deck 8 inches to 12 inches above the bucket deck, which places the shrub pad closer to the overhang and increases the severity of the angle of bend.

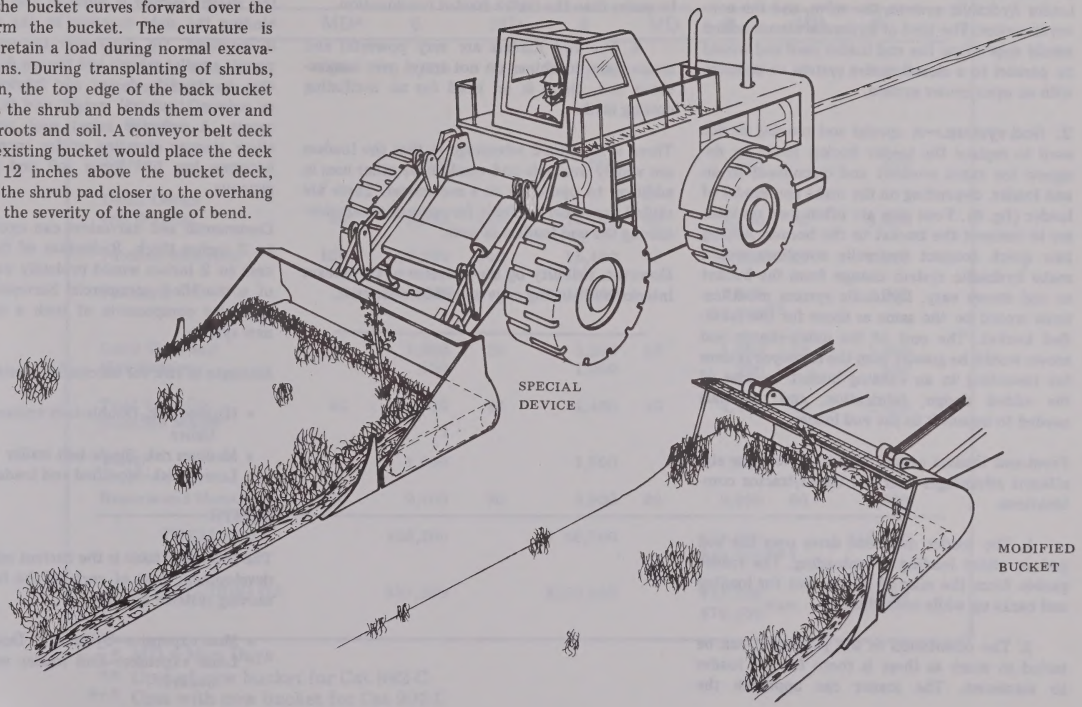


Figure 8.–Front-end loader sodder.

The only modification to the bucket would be holes drilled to bolt down the conveyor system and to provide access for hydraulic lines to the conveyor drive motor. Modifications to the end loader would be addition of a four-way, three-position hydraulic valve, and hoses between the loader hydraulic system, the valve, and the conveyor motor. The kind of hydraulic circuit added would depend on the end loader used and would be parallel to a closed center system or in series with an open center system.

2. Sod system.—A special sod moving device used to replace the loader bucket could be designed for rapid connect and disconnect to an end loader, depending on the make and model of loader (fig. 8). Four pins are often used on loaders to connect the bucket to the booms. Adding two quick connect hydraulic couplings would make hydraulic system change from the bucket to sod mover easy. Hydraulic system modifications would be the same as those for the modified bucket. The cost of the quick-change sod mover would be greater than the conveyor system for mounting in an existing bucket because of the added design, fabrication, and materials needed to mount it to the end loader.

Front-end loaders as sod movers have some significant advantages over the trailer/tractor combinations.

1. The loader does not drive over the sod pad in either loading or unloading. The loader pushes from the rear of the bucket for loading and backs up while unloading.

2. The orientation of sod placement can be varied as much as there is room for the loader to maneuver. The loader can approach the placement anywhere from parallel to perpendicular to the placement of previously moved sod pads.

3. The transplant system is ahead of the operator so that control of the transplanter should be easier than the trailer tractor combination.

4. The end loaders are very powerful and because the machines do not travel over unexcavated sod, there is no need for an oscillating cutting blade.

There is an added advantage in that the loaders are widely available and would have other uses in addition to operating as a sod mover. There are skilled personnel available for operating and maintaining the end loaders as well.

However, visibility by the operator of the bucket interior and cutting edge would be restricted.

FEASIBILITY

The feasibility of any of the systems described could be enhanced by a reduction of the requirements. Reducing sod thickness would have the most significant effect. As thickness is reduced, the weight carried is reduced and the effect of binding the slabs together by the root systems is increased. On the trailer system this would permit smaller wheels and tires in dual configuration to simplify design and fabrication as well as reduce structural weight and power requirements. A cohesive intact root system should allow steeper elevating angles because the slab becomes less like loose soil and more homogeneous.

Commercial sod harvesters can excavate sod up to 2 inches thick. Reduction of the soil thickness to 2 inches would probably permit the use of a modified commercial harvester or the use of major components of such a machine on a new system.

Estimate of risk for successful development:

- Highest risk--Double-belt trailer and cylinder trailer
- Medium risk--Single-belt trailer
- Lowest risk--Modified end loaders

COSTS

The following table is the current estimate of the development cost of each of the four basic sod moving systems described.

- Most expensive--Cylinder or Double-belt
- Least expensive--End loader with modified bucket

Table 2.-- Cost comparison

	Trailer				End Loader			
	Single Belt		Cylinder or Double Belt		Modified Bucket		Replace Bucket	
	MD*	$	MD	$	MD	$	MD	$
Design-- Stress & Kinematic Analysis, Trade-off Studies, Design Sketches	60	$ 6,600	70	$ 7,700	40	$ 4,400	50	$ 5,500
Travel		500		500		500		500
Detail Design and Drafting	90	9,900	110	12,100	40	4,400	60	6,600
Purchase Materials	120	13,200	140	15,400	75	8,250	90	9,900
Fabricate		10,000		12,000		4,000 17,000**		8,000
Local Tests and Modifications	15	1,650 500	20	2,200 1,000	15	1,650 500	15	1,650 500
Field Tests On Modified Model	40	4,400	40	4,400	40	4,400	40	4,400
Travel		1,550		1,500		1,500		1,550
Reports and Manuals	90	9,900	90	9,900	90	9,900	90	9,900
TOTAL COST		$58,200		$ 66,700		$39,500 $56,500***		$48,500
INCLUDING GA		$87,300		$100,050		$59,250 $76,250***		72,750

* MD = Man Days
** Cost of new bucket for Cat 992-C
*** Cost with new bucket for Cat 992-C

FOOTNOTES

[1]Sindelar, B.W., R.L. Hodder, and M.E. Majerus. 1973. Surface mined land reclamation research in Montana. Montana Agricultural Experiment Station, Bozeman, Mont.

[2]Knudson, Robert J. 1978. Telephone conversations with the Representatives of the Nott Company, Hibbing, Minn. and the B.F. Goodrich Corporation Field Representative in Billings, Mont.

[3]Karsky, R.J. 1973. The effects of direction of oscillation and blade angle on draft of a simple vibratory tillage tool. M.S. Thesis. Univ. Minnesota, St. Paul.

[4]Gill, W.R. and G.F. Vandenberg. (n.d.) Soil dynamics in tillage and traction. USDA Agricultural Research Service Handbook No. 316.

[5]Knudson, Robert J. 1978. Telephone conversation with Ditch Witch dealer, Helena, Mont.

BLM Library
Denver Federal Center
Bldg. 85, OC-521
P.O. Box 25047
Denver, CO 80225